

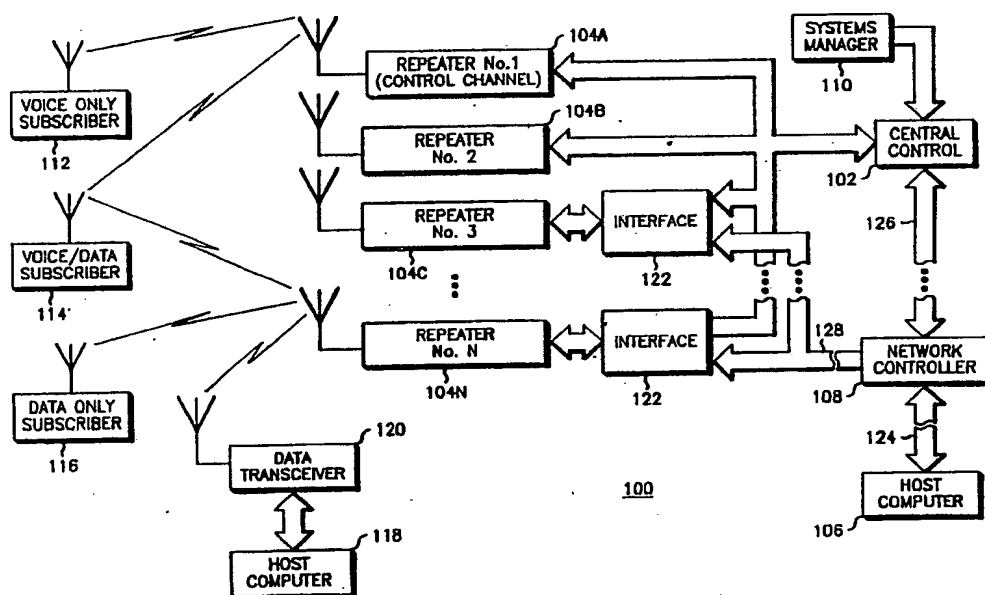


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(54) Title: TRUNKED COMMUNICATION SYSTEM FOR VOICE AND DATA



(57) Abstract

A trunked voice/data communication system (100) is provided wherein a plurality of the trunked voice repeaters (104) are adapted (122) to accommodate both voice and data traffic. Data channels are assigned for a dynamically varying period of time depending upon traffic load or time of day. Once a data channel is established, any data unit (114 or 116) may transmit without re-requesting a data channel. In this way, the protracted request-grant delay times are avoided. After the time interval, or if higher priority voice traffic exists, the data channel is reallocated to voice traffic. Thereafter, another data channel request may result in a data channel grant for another time interval.

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TRUNKED COMMUNICATION SYSTEM
FOR VOICE AND DATA

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Technical Field

This invention relates generally to trunked communications systems and more particularly to trunked communication systems that transceive both voice and data.

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Background Art

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In a basic RF trunked system there exists a high degree of flexibility to partition voice conversations between different groups so that no one group of users is specifically aware when another group of users makes use of the system. Typically, these groups are subdivided into subgroups so that calls may be made upon either a group, subgroup or individual basis depending upon the type of communication desired by an initiating subscriber.

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To establish a voice communication between a group of units operating on a trunked system, a subscriber unit transmits a data packet called an "inbound signalling word" (ISW) on a control channel that is maintained for such purposes. The ISW contains at

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- 2 -

least the requesting unit's unique ID code, which may contain or be used to obtain the requesting subscriber's current talk-group. The request is forwarded to a central controller, which decodes the request, and
5 transmits on the control channel a data packet called an "outbound signalling word" (OSW) to all subscriber units, which continuously monitor the control channel when not participating in a voice conversation. The OSW is a channel grant which contains the talk-group code of the
10 requesting unit, and the voice channel number assigned for the conversation. The OSW causes the requesting unit to move to the voice channel and commence transmitting, while simultaneously causing all other subscriber units in the same talk-group to move to the voice channel as
15 listening units. In this way a group call is set up. If, however, all voice channels are in use when a subscriber unit transmits an ISW, the central controller typically sends the requesting subscriber a "busy OSW".

In addition to voice messages, it is desirable to
20 send data information across a trunked radio channel. In some data systems, a subscriber unit obtains a trunked data communication channel via the same procedure used to obtain a voice channel. However, this practice is inefficient and spectrally wasteful, due to the time it
25 takes for a requesting subscriber to transmit an ISW and receive a channel grant OSW from the central and the time it takes to setup and clean-down calls on a voice channel. At contemporary data transmission rates, it is anticipated that an entire typical data message would
30 take substantially less time to transmit than the time required to set-up a channel (approximately .5 seconds). Thus, assigning a data channel pursuant to the same procedure as assigning a voice channel would be wasteful of spectrum and consume precious system time that could
35 be better used to transmit data messages.

Other trunked communication systems desirous to accommodate data traffic have permanently dedicated one

- 3 -

or more channels to handling data traffic. While this avoids the access time problem noted above, this technique is contrary to the basic principles of trunked communication systems, which strive to allocate channel resources across a plurality of users as required. Therefore, the practice of having dedicated data channels, permanently removed from the channel allocation "pool" of frequencies, is wasteful of spectral resources and leads to inefficient system operation. Moreover, the dedicated data channel systems lack the capacity to dynamically redistribute or allocate the data traffic load across the available data channels. Such systems typically permanently assign a subscriber unit to a data channel thereby building in future problems as the number of data subscribers increases on a particular channel.

Accordingly, there exists a need for a trunked communication system that can accommodate both voice and data signals, and that operates in true trunked manner to efficiently utilize spectral resources.

Summary of the Invention

Accordingly, it is an object of the present invention to provide an improved trunked communication system.

It is a further object of the present invention to provide a trunked communication system capable of accommodating both voice and data traffic.

It is a further object of the present invention to accommodate data traffic without permanently removing one or more channels from the trunked channel resources.

It is yet another object of the present invention to provide a voice/data subscriber unit capable of operating in the trunked communication system of the present invention.

- 4 -

It is yet a further object of the present invention to provide a voice/data subscriber unit capable of operating in a plurality of data modes.

5 It is yet another object of the present invention to provide a trunked voice/data communication system which accommodates prior voice only and data-only subscribers.

10 It is yet a further object of the present invention to provide a voice/data trunked communication system which permits prior data-only subscribers to communicate notwithstanding the absence of an assigned data channel.

15 It is yet a further object of the present invention to provide a trunked communication system that minimizes spectrally wasteful access time while providing trunked data communication.

Briefly, according to the invention, a trunked voice/data communication system is provided wherein a plurality of trunked voice repeaters are adapted to
20 accommodate both voice and data traffic. Data channels are thereafter assigned for a dynamically varying period of time depending upon, for instance, traffic load or time of day. Once the system establishes a data channel, any subscriber data unit may transmit without
25 re-requesting a data channel. In this way, the protracted request-grant delay times are avoided. After the time interval, or if higher priority voice traffic exists, the data channel may be reallocated to voice traffic. Thereafter, another data channel request can
30 result in a similar data channel grant for another time interval on another, or the same, channel.

Brief Description of the Drawings

35 The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with

- 5 -

further objects and advantages thereof, may be understood by reference to the following description, taken in conjunction with the accompanying drawings, and the several figures in which like reference numerals identify like elements, and in which:

Figure 1 is a block diagram of the trunked communication system of the present invention;

Figures 2a-2c are flow diagrams illustrating the steps executed by the fixed-end equipment of Figure 1;

Figures 3a-3e are flow diagrams illustrating the steps executed by the voice/data subscribers of Figure 1;

Figure 4 is a state diagram illustrating the operation of the voice/data subscribers of Figure 1.

15 Detailed Description of the Preferred Embodiment

Referring now to the drawings, and in particular to Figure 1, there is shown a block diagram of the trunked voice/data communication system (100) of the present invention. The centralized or fixed-end equipment comprises a central controller 102, which is responsible for allocating the channel resources (represented here by repeaters 104a-104N) amongst the many subscriber units. Of the available communication channels, one (repeater 104a) is selected to be a voice control channel, which will communicate with any trunked subscriber capable of transmitting voice traffic. Typically, the particular repeater selected to be the control channel (104a) is periodically changed as a control measure.

Preferably, each of the repeaters 104a-N are capable of operating as a voice channel, control channel, or data channel. To accommodate data traffic, such repeaters are equipped with a data interface 122. The data interfaces 122 are responsible for encoding outbound data, decoding and error correcting inbound data, repeater control, and providing an interface between the

- 6 -

repeater and the network controller 108. Alternately, a predetermined subset of the total number of repeaters may be equipped for data or use as a control channel.

5 The data network comprises at least one host computer 106, which is coupled (i.e., wireline host) to a network controller 108. The network controller 108 is responsible for data traffic routing and communicating with the central controller 102 to request the allocation of a data channel. Those skilled in the art will
10 appreciate that if the host computer 106, the network controller 108 and the central controller 102 are co-located, the intercouplings (124-128) may be direct. However, should remote locations be desired, such communications may be maintained through the use of data
15 modems as is known in the art. Optionally, or additionally, the trunked voice/data communication system 100 may employ one or more radio frequency (RF) coupled host computers 118. The RF host 118 communicates as a trunked control station via any suitable data transceiver
20 120. The primary difference between the wireline host 106 and the RF host 118 is that the data subscribers communicate directly (i.e., via both the inbound and outbound frequencies of a data equipped repeater) with the RF host, whereas the wireline host 106 transceives
25 all information via the inbound or outbound frequency of a data equipped repeater. Accordingly, the data network of the present invention may employ several computers in either a centralized or distributed processing arrangement.

30 Generally, the fixed-end equipment also includes a system manager console 110 that enables the supervisor of a communication service provider to set a number of operational parameters that control the operation of the trunked communication system. Typical examples of such
35 parameters include the maximum number of assignable data channels (if any), whether voice or data will be the priority traffic, and various threshold values that

- 7 -

control when data channels may be added or reallocated to voice traffic. Thus, at any particular time, the trunked communication system of the present invention need not have any channels allocated for data traffic.

5 Conversely, if voice traffic is low, or if data traffic enjoys a priority status or is particularly heavy, one or more channels may be allocated for data communication.

According to the present invention, a predetermined channel ordinarily comprises the first
10 channel to be allocated for data. Preferably, this first assigned data channel (hereinafter "the master data channel") has the same frequency as any single frequency data-only subscribers (116) to provide maximum compatibility with existing data equipment. Alternately,
15 a random channel may be the first assigned data channel; however, the multi-channel data-only subscribers may have to scan the available channels to find it. Thus, the present invention prefers to first assign a selected channel, and, thereafter, assign any other data equipped
20 (122) channel as an additional data channel.

The present invention allocates data channels for a time interval determined by either the system manager or a default parameter. The length of the allocation period may vary with the time of day, system loading or
25 other such parameters. By reserving a channel for data use over a time period, data channel requests are minimized and spectral efficiency is maximized since a data subscriber need not request a data channel for each separate data transmission.

30 As a general principle, the goal of any trunked communication system is to effectively allocate the limited channel resources amongst a plurality of subscriber units. The present invention contemplates three classes of subscriber units: voice-only
35 subscribers 112, voice/data subscribers 114, and data-only subscribers 116. The voice-only subscribers 112 are contemplated to be any existing trunked

- 8 -

subscriber unit having a compatible signalling protocol to allow interaction with the system (100). The data-only subscribers (116) are contemplated to be any multiple or single channel data transceivers such as the
5 KDT 800TM, manufactured by Motorola, Inc., or functional equivalent. Of course, receive-only data devices, such as any of the Motorola family of display pagers, may also operate to receive paging data over an assigned data channel.

10 Additionally, the present system contemplates a voice/data subscriber 114 capable of operating within the trunked system 100. In this way, the trunked system of the present invention accommodates existing equipment, while providing enhanced communication capabilities.
15 Subscriber units are typically comprised of either mobile, portable or control stations. Typically, mobile units are understood to be transceivers designed to operate in a vehicle. A portable unit is typically understood to be a transceiving or receive-only device
20 designed primarily to be carried on or about the person. Control stations are usually permanent or semi-permanent installations in buildings or other such fixed locations. These are collectively referred to herein as subscriber units, which communicate with one another through the
25 fixed-end equipment.

Referring now to Figures 2a-2c, the steps executed by the fixed-end equipment are illustrated. In step 200, the central 102 receives a data channel request either from the network controller 108 or from a
30 voice/data subscriber 114. The voice/data subscriber 114 may communicate such a data channel request via the control channel 104a when the subscriber has data to transmit. The network controller 108 may communicate a similar request over the connection 126 to the central
35 controller in several circumstances to be hereinafter described.

- 9 -

For a single channel data-only subscriber 116 to request a channel, a request may be made over the master data channel to the network controller since the data-only subscribers cannot transceive on the voice control channel. According to the present invention, the data-only subscribers may communicate with the network controller irrespective of the fact that no data channels are currently assigned. The reason for this is that a de-keyed repeater continues to operate as a receive-only device. In this way, the network controller 108 can "hear" a data channel request from a data-only subscriber 116 and repeat it to the central controller 102. If a data channel is available, the central controller will format and return a data channel grant both over the control channel 104a (to the voice/data subscribers 114) and to the network controller 108 via the connection 126.

Accordingly, decision 202 tests to determine whether a data channel has been granted by the central. If not, the routine proceeds to step 204, where the network controller (or data subscriber) waits a predetermined time interval before returning to reference letter A to again request a data channel. If the central 102 grants a data channel, the routine proceeds to step 206, where the central transmits the data channel assignment over the control channel 104a and to the network controller 108. Thereafter, data-only subscribers 116 and voice/data subscribers 114 operating in the data mode may communicate over any of the assigned data channels.

Data operation may continue without further data channel requests for the allocated time period, which may be determined by the system manager 110. When the allocation time period has expired, or higher priority voice traffic exists, the central controller 102 transmits an instruction to the network controller 108 to relinquish the data channel. Thus, decision 208 tests to see whether the central has so instructed. If so, the

- 10 -

routine proceeds to reference letter B where the channel is relinquished. If not, the routine proceeds to decision 210, which tests to see whether an additional data channel is needed.

5 If the data channel traffic on any existing data channel exceeds a predetermined threshold, the network controller 108 may request an additional data channel from the central controller 102. To do this, the network controller proceeds to reference letter A to transmit
10 another data channel request to the central. If another data channel is available for data traffic, the central may assign an additional data channel.

 Of course, when another data channel is assigned, the data traffic load, per channel, is uneven.
15 Accordingly, the present invention contemplates leveling the data load among the available data channels to maximize data communication. Two preferred methods for allocating data channels and leveling the data traffic load is described in two co-pending applications filed on
20 an even date herewith. The first is by Garry Hess (attorney docket number CM-00248H), and the second is by Ken Zdunek (attorney docket number CM-00262H), and both are entitled "Method For Dynamically Allocating Data Channels On A Trunked Communication System", with each
25 being assigned to the same assignee as the present invention. These cases are hereby incorporated by reference as if fully set forth herein.

 Referring again to Figure 2, if decision 210 determines that another data channel is not needed, the
30 routine proceeds to reference letter D, which forms the fixed-end operational loop comprising decisions 208 and 210. The fixed-end remains on this loop until either a data channel is requested to be relinquished or another data channel is requested.

35 Referring now to Figure 2b, the steps executed to relinquish a data channel are shown. Assuming that the central controller 102 has requested the network

- 11 -

controller 108 to give up a data channel, the network controller transmits a "return to control channel" command 212 over the data channel to be relinquished. All data compatible subscribers receiving this command
5 return to the control channel 104a. Of course, single channel data-only subscribers continue to monitor their particular single frequency. In step 214, the network controller 108 releases the data channel to the central controller. In step 216, the central 102 may now assign
10 this channel for a voice call. After this, decision 218 determines whether there are remaining data channels. If the network controller 108 has released only one of several data channels, the routine proceeds to reference letter D of Figure 2a to continue data operation.
15 However, if the sole data channel was relinquished, the routine proceeds to reference letter C of Figure 2c.

Referring now to Figure 2c, the network controller 108, after relinquishing the sole data channel, starts a request timer in step 220. Decision
20 222 determines whether this timer has expired. If so, the routine returns to reference letter A to request a data channel. If the timer has not expired, the network controller 108 determines whether the host computer 106 has any data for transmission. If the determination of
25 decision 224 is that the host has data to transmit, the routine proceeds to reference letter A to request a data channel. Otherwise, the network controller determines in decision 226 whether a data message has been received from a data-only subscriber or an RF host computer. If
30 the determination of decision 226 is that such a data message was received, the network controller 108 "knows" that the channel which carried the data is idle and that a data-only subscriber wishes to communicate. Accordingly, the routine returns to reference letter A,
35 where the network controller requests a data channel to allow it to communicate with the data-only subscriber. However, if the network controller 108 has received no

- 12 -

such data message, the routine continues by returning to reference C, which forms a waiting loop until either the request timer expires or some data activity occurs.

Referring now to Figures 3a-3e, the steps
5 executed by the data/voice subscriber 114 are shown. In step 300 of Figure 4a, the subscriber unit powers up. During power up, the subscriber unit may execute any self-check routines and initialize operational flags and variables. During this time, the subscriber unit
10 determines in decision 302 whether to operate primarily in the voice mode. If so, decision 302 transfers control to reference letter E for voice mode operation. If not, decision 304 tests whether the subscriber operates primarily in the data mode. If decision 304 determines
15 that the subscriber normally operates in the data mode, the routine proceeds to reference letter F for data mode operation.

Alternately, the subscriber unit may use its last mode of operation. Thus, if the last communication was a
20 voice call, the subscriber unit would operate in the voice mode. Conversely, if the last communication was a data transmission, the subscriber would operate in the data mode. Decision 306 determines if the last mode operational option is selected. If not, the routine
25 proceeds to step 308, which signals that a unit fault has occurred for failure to determine one of the only three available modes of operation. However, if the determination of decision 306 is that the last mode was selected, decision 310 determines whether the last
30 activity was a voice call. If so, the routine proceeds to reference letter E for voice mode operation. If the determination of decision 310 was that a data transmission was last made, the routine proceeds to reference letter F for data mode operation.

35 Referring now to Figure 3b, the steps executed by a voice/data subscriber 114 in the voice mode are shown. In step 312, the subscriber unit monitors the control

- 13 -

channel. According to the present invention, the voice mode subscriber unit must at all times be either monitoring the control channel, or participating in a voice call on one of the available voice channels.

5 Accordingly, the voice mode subscriber continuously monitors the control channel until a command is received or the operator transmits. According, decision 314 determines whether the subscriber operator has pressed the push-to-talk (PTT) switch. If so, step 316 transmits
10 a voice call request over the control channel to the central controller 102. Following this, the subscriber returns to step E to monitor the control channel. If the PTT switch was not newly depressed, the routine proceeds to decision 318 to determine whether a channel assignment
15 has been received over the control channel.

If the determination of decision 318 is that a channel assignment has been received, the routine proceeds to step 320, where the subscriber goes to the assigned voice channel to participate in the call. After
20 the completion of the call, the routine returns to reference letter E to again monitor the control channel.

If the subscriber operator has entered data for transmission, decision 322 changes the subscriber's operating mode to the data mode and the routine proceeds
25 to reference letter F. Decision 324 determines whether the voice mode subscriber has received a command over the control channel to go to the data mode to receive a message from the host computer 106. Preferably, the central 102 keeps track of the subscribers operating in
30 the voice mode. The network controller 108 thereby avoids wasted transmission time by not transmitting a data message to a subscriber known not to be monitoring one of the assigned data channels. Thus, the network controller can request the central to command a voice
35 mode subscriber to an assigned data channel to receive a data message. Upon receiving such a command, decision

- 14 -

324 routes the program to reference letter G to participate in the data transmission.

While operating in the voice mode, any subscriber unit monitoring the control channel may receive any data
5 channel allocation information transmitted from the central 102 over the control channel. Accordingly, decision 326 tests to determine if such data channel allocation information has been received. If so, the routine proceeds to step 328, where the information is
10 stored for later use. If not, decision 326 routes the program to reference letter E, where the subscriber continues to operate in the loop of Figure 3b.

Referring now to Figure 3c, the steps executed by the voice/data subscriber 114 while in the data mode are
15 shown. According to the present invention, a voice/data subscriber may operate in the data mode in any one of three ways: the data monitor mode, the voice monitor mode, and the last channel mode. In the data monitor mode, the subscriber unit monitors one of the assigned
20 data channels until commanded to return to the control channel or the voice mode. In the voice monitor data mode, a subscriber unit may operate in the data mode, while monitoring the control channel, thereby enabling rapid participation in any voice messages. In the voice
25 monitor mode, a subscriber may momentarily go to the data channel to transceive data and thereafter immediately return to the control channel upon completion of the transmission or reception. Alternately, as the name implies, the last channel mode comprises the subscriber
30 monitoring either the data channel or the control channel depending upon the last communication type.

Accordingly, decision 330 determines whether the subscriber should monitor the data channel. An affirmative decision results for a data monitor mode
35 subscriber, or a last mode subscriber that had previously transmitted or received on the data channel. In all other cases, the determination of decision 330 causes the

- 15 -

subscriber to monitor the control channel (step 332). Once monitoring the control channel, the subscriber continuously attempts to decode commands and channel assignments. Accordingly, decision 334 determines
5 whether a voice mode command has been received. A voice mode command causes the subscriber to revert to the voice mode as illustrated in Figure 3b. Failing this, decision 336 determines whether a data channel assignment has been received from the central controller 102.

10 As previously mentioned, the central 102 keeps track of the subscribers operating in the voice mode. The network controller 108 avoids wasted transmission time by not transmitting a data message to a subscriber known not to be monitoring one of the assigned data
15 channels. Thus, the network controller requests the central to command a voice mode subscriber to an assigned data channel to receive a data message. Accordingly, if decision 336 determines that a data channel command has been received, control reverts to reference letter F,
20 wherein the subscriber moves to monitor the data channel. If not assigned to a data channel, the routine proceeds to decision 338, which determines whether new data channel allocation information has been received. If so, the information is conveniently stored in step 340 and
25 the routine returns to the reference letter H to again monitor the control channel.

Decision 342 determines whether the operator has activated the push-to-talk switch to initiate a voice conversation. If the determination of decision 342 is
30 that the push-to-talk switch has been depressed, the routine proceeds to reference letter E of Figure 3b, thereby switching to the voice mode of operation to participate in a voice call. A high degree of flexibility is afforded in the present invention by
35 allowing the subscriber unit to operate in the data mode, while monitoring the control channel. Thus, in decision 344 the subscriber determines whether a voice channel

- 16 -

grant has been received on the control channel. If so, subscriber unit operates (step 346) to process the call and then returns to the data mode of operation to monitor the control channel (reference letter H).

5 If no voice grant has been received, decision 348 determines whether the subscriber has data to transmit. If so, the routine proceeds to reference letter F, where the subscriber goes to the data channel to await data transmission. If a subscriber has no data to transmit,
10 the routine reverts to reference letter H to continually monitor the control channel, while checking for commands and assignments in the subscriber unit's operational loop.

 Assuming an affirmative determination from
15 decision 330, the subscriber unit monitors an assigned data channel (step 350). Step 352 starts an inactivity timer, which causes the subscriber to revert to the control channel if there has been no data activity by any subscriber for the predetermined timer interval.
20 Accordingly, decision 354 determines whether there is any current activity on the data channel. If so, the routine proceeds to reference letter I, where the subscriber unit operates to receive the data and process it. If there is no activity, the routine proceeds to decision 356, which
25 determines if the subscriber has any data to transmit to the host computer 106 (or 118). If so, the routine proceeds to reference letter J for the subscriber data mode transmission routine. If the subscriber has no data to transmit, decision 358 determines whether the
30 subscriber's operator has activated the PTT switch. If so, the routine proceeds to reference letter E, thereby changing to the voice mode. If the PTT was not activated, decision 359 determines whether the timer has expired. If the determination of decision 359 is that
35 the timer has not expired, the routine proceeds to reference letter K to form a loop checking for data channel activity. If, however, there has been no data

- 17 -

activity for the period of the timer, decision 359 routes control to reference letter H, where the subscriber unit begins to monitor the control channel (step 332), while remaining in the data mode.

5 Referring now to Figure 3d, the data mode receive sequence is illustrated. In step 360, the data is extracted from the data channel and received by the subscriber unit. Decision 362 determines whether the received data has an ID portion corresponding to the
10 subscriber's ID. If not, either the data has been received in error or the data was not addressed to this subscriber unit. Accordingly, step 364 resets the activity timer and control is returned to reference letter K to again monitor activity on the data channel.

15 If the determination of decision 362 is that the ID is valid, the subscriber unit processes the information to receive the data and/or commands from the host computer 106. Decision 366 determines whether a voice mode command has been received. If so, the routine
20 proceeds to reference letter E of Figure 3b, where the subscriber unit switches to operate in the voice mode. If the determination of decision 366 is that a voice mode command was not received, decision 368 determines whether a "go-to control channel" command was received. If so,
25 subscriber unit remains in the data mode, but adapts to monitor the control channel. Accordingly, program control is routed to reference letter H.

If the received data did not contain a voice mode or go-to control channel command, the routine proceeds to
30 decision 370, which determines if the subscriber operator has pressed the push-to-talk switch to initiate a voice call. If the subscriber has initiated a voice call, the routine proceeds to step 371, which stores any received data for later processing, and returns control to refer-
35 ence letter E of Figure 3b to process the voice call.

If the operator has not initiated a voice call, step 372 processes the received data in accordance with

- 18 -

any instructions previously received or contained in the received data. Step 374 resets the data activity timer since data activity was recently received.

Decision 376 determines whether the subscriber unit operates in the voice monitor mode. If so, the routine proceeds to reference letter H to monitor the control channel. However, if the subscriber is a data monitor subscriber or a last mode subscriber, decision 376 returns control to reference letter F, and the data channel is monitored (step 350).

Referring now to Figure 3e, the data transmit sequence of the data mode is illustrated. In step 378, the subscriber unit transmits the data onto the data channel using any suitable form of data modulation.

Decision 380 determines whether the subscriber's transmission has collided with the transmission of another subscriber. Such collision detection schemes are well known in the art and the selection of any particular one scheme is not essential to the understanding of the invention. Assuming the determination of decision 380 was that a collision had occurred, the routine proceeds to step 382, which waits an arbitrary interval before returning control to reference letter J to retransmit the data. If, however, no collision was detected, the routine proceeds to step 384, which resets the activity timer since the subscriber has just transmitted on the data channel. In step 386, the subscriber determines whether it operates in the voice monitor mode or whether it should continue to monitor the data channel (i.e., either last used mode or the data monitor mode). If the determination of decision 386 is that the subscriber should monitor the control channel, the routine proceeds to reference letter H. Otherwise, the routine proceeds to reference letter F to monitor the data channel.

Referring now to Figure 4, a state diagram illustrating the operation of the subscriber unit is shown. According to the present invention, the

- 19 -

subscriber unit must always be on either the control channel, an assigned voice channel or an assigned data channel.

5 In state 402, the subscriber is operating in the voice mode on the control channel. The subscriber unit may participate in the voice call in state 404 by receiving a channel grant, and returns to the control channel state 402 by receiving a disconnect or timing out at the end of the call. Additionally, the subscriber may
10 receive priority messages while participating in a voice call. Accordingly, if the subscriber receives a priority data mode command, the subscriber may abandon the voice call and enter state 406.

In state 406, the subscriber operates in the data
15 mode, while monitoring the control channel. The subscriber may enter and leave this state via command of the host computer via the network controller and central controller. The commands can either return the subscriber to the voice mode in state 402 or remain in
20 the data mode monitoring the data channel in state 408. In either of the data mode states (406 or 408), a push-to-talk command returns the subscriber to state 402. Additionally, receiving a channel grant rapidly moves the subscriber from state 406 directly to state 404 to
25 participate in a voice call. Thus, the voice/data subscriber may move from one state to another state along any of the defined paths of the state diagram 400.

While a particular embodiment has been described and shown, it will be understood that the present
30 invention is not limited thereto since many modifications can be made. It is therefore contemplated to cover by the present application any and all such modifications that fall within the true spirit and scope of the basic underlying principles disclosed and claimed herein.

35 What is claimed is:

- 20 -

Claims

1. A trunked voice/data communication system, comprising:

5 a plurality of repeaters, at least one of which is constructed and arranged to transceive data information;

a plurality of subscriber units constructed and arranged to communicate information on an assigned repeater in either a voice mode or a data mode;

10 at least one central controller coupled to each of said plurality of repeaters, for allocating said plurality of repeaters among said plurality of subscriber units;

15 a network controller, coupled to said central controller and said at least one of said plurality of repeaters constructed and arranged to transceive data, for controlling data information transfers; and

20 at least one computer, coupled to said network controller, for communicating with any of said plurality of subscriber units operating in said data mode.

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2. In a trunked voice/data communication system, having at least one central controller for allocating a plurality of communication channels among a plurality of subscriber units, and at least one network controller for controlling data transfers between a computer and said subscriber units, a method for allocating a data channel comprising the steps of:

at the network controller:

- 10 (a) transmitting a data channel request to the central controller;
- (b) receiving a data channel grant from said central controller;
- (c) receiving a data channel relinquish request from the central controller;

15 at the central controller:

- (a) receiving said data channel request from the network controller;
- (b) allocating, for a time interval, a repeater for data communication;
- 20 (c) transmitting said data channel grant to the network controller;
- (d) transmitting, after said time interval, said data channel relinquish request to said network controller.

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3. In a trunked voice/data communication system, having at least one central controller for allocating a plurality of communication channels among a plurality of subscriber units, and at least one network controller for controlling data transfers between a computer and said subscriber units, a method for allocating a data channel comprising the steps of:

at a subscriber unit:

- 10 (a) transmitting a data channel request to the central controller over a control channel;
- (b) receiving a data channel grant from said central controller from said control channel;

at the central controller:

- 15 (a) receiving said data channel request from the subscriber unit over said control channel;
- (b) allocating, for a time interval, a repeater for data communication;
- 20 (c) transmitting said data channel grant to the subscriber unit over said control channel;
- (d) transmitting, after said time interval, a data channel relinquish request to said
- 25 network controller;

at the network controller:

- (a) receiving said data channel relinquish request from the central controller.

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4. The method of claim 3, wherein the network controller step (a) includes the step of transmitting said data channel relinquish request to the subscribers over said data channel.

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5. The method of claim 4, which includes the subscriber step of: (c) receiving said data channel relinquish request over said data channel.

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6. In a trunked voice/data communication system, having at least one central controller for allocating a plurality of communication channels among a plurality of subscriber units, and at least one network controller for
5 controlling data transfers between a computer and said subscriber units, a method for allocating a data channel comprising the steps of:

at a data-only subscriber unit:

10 (a) transmitting, regardless of whether a data channel has been assigned, a request to transmit data to the network controller over a predetermined channel;

at the network controller:

15 (a) receiving said request to transmit data from said predetermined channel;

(b) transmitting a data channel request to the central controller;

(c) receiving a data channel grant from the central controller;

20 (d) receiving a data channel relinquish request from the central controller;

at the central controller:

(a) receiving said data channel request from the network controller;

25 (b) allocating, for a time interval, a repeater for data communication;

(c) transmitting said data channel grant to the network controller;

30 (d) transmitting, after said time interval, said data channel relinquish request to said network controller.

AMENDED CLAIMS

[received by the International Bureau on 09 August 1988 (09.08.88)
new claims 7-16 added; other claims unchanged (10 pages)]

7. A voice/data communication system for providing communication between a plurality of subscriber units constructed and arranged to communicate voice information on an assigned voice channel, or data information on shared data channels, said system comprising:

5 a plurality of transceivers, at least one of which is constructed and arranged to transceive data information;

10 at least one central controller coupled to each of said plurality of transceivers, for allocating said plurality of transceivers among said plurality of subscriber units either as an assigned voice channel or as a data channel shared by said plurality of subscriber units;

15 a network controller, coupled to said central controller and any of said plurality of transceivers constructed and arranged to transceive data from any of said plurality of subscriber units.

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8. A trunked voice/data communication system having at least one central controller for allocating a plurality of communication channels among a plurality of subscriber units, and at least one network controller for controlling data transfers between a computer and at least one of said plurality of subscriber units, said system comprising:

at the network controller:

means for transmitting a data channel request to the central controller:

means for receiving a data channel grant from said central controller;

means for receiving a data channel relinquish request from the central controller;

at the controller:

means for receiving said data channel request from the network controller;

means for allocating, for a time interval, a repeater for data communication between said computer and at least one of said plurality of subscriber units;

means for transmitting said data channel grant to the network controller;

means for transmitting, after said timer interval, said data channel relinquish request to said network controller.

9. A trunked voice/data communication system, having at least one central controller for allocating a plurality of communication channels among a plurality of subscriber units, and at least one network controller for controlling data transfers between a computer and at
5 least one of said plurality of subscriber units, said system comprising:

at a data-only subscriber unit:

means for transmitting, regardless of whether a data channel has been assigned,
10 a request to transmit data to the network controller over a predetermined channel;

at the network controller:

means for receiving said request to transmit data from said predetermined
15 channel;

means for transmitting a data channel request to the central controller;

means for receiving a data channel grant from the central controller;
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means for receiving a data channel relinquish request from the central controller;

at the central controller:

means for receiving said data channel request from the network controller;
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means for allocating, for a time interval, a repeater for data

communication between said computer and at least said data-only subscriber unit;
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means for transmitting said data channel grant to the network controller;

means for transmitting, after said time interval, said data channel relinquish request to said network controller.
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10. A trunked voice/data communication system, having at least one central controller for allocating a plurality of communication channels among a plurality of subscriber units, and at least one network controller for controlling data transfers between a computer and at least one of said plurality of subscriber units, said system comprising:

at a subscriber unit:

means for transmitting a data channel request to the central controller over a control channel;

means for receiving a data channel grant from said central controller from said control channel;

at the central controller:

means for receiving said data channel request from the subscriber unit over said control channel;

means for allocating, for a time interval, a repeater for data communication between said computer and at least one of said plurality of subscriber units;

means for transmitting said data channel grant to the subscriber unit over said control channel;

means for transmitting, after said time interval, a data channel relinquish request to said network controller;

at the network controller:

means for receiving said data channel relinquish request from the central controller.

11. In a trunked communication system, having at least one central controller for allocating a plurality of communication channels among a plurality of subscriber units, and at least one network controller for controlling data transfers between a computer and at least one of said plurality of subscriber units, a method for allocating a data channel comprising the steps of:
- at the network controller:
 - (a) transmitting a data channel request to the central controller;
 - at the central controller:
 - (a) receiving said data channel request from the network controller;
 - (b) allocating, for a time interval, a repeater for data communication between said computer and at least one of said plurality of subscriber units.

12. A trunked communication system, having at least one central controller for allocating a plurality of communication channels among a plurality of subscriber units, and at least one network controller for controlling data transfers between a computer and at least one of said plurality of subscriber units, said system comprising:

at the network controller:

means for transmitting a data channel request to the central controller;

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at the central controller:

means for receiving said data channel request from the network controller;

means for allocating, for a time interval, a repeater for data

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communication between said computer and at least one of said plurality of subscriber units.

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13. In a trunked communication system, having at least one central controller for allocating a plurality of communication channels among a plurality of subscriber units, and at least one network controller for controlling data transfers between a computer and at least one of said plurality of subscriber units, a method for allocating a data channel comprising the steps of:

at a subscriber unit:

(a) transmitting a data channel request to the central controller over a control channel;

(b) transmitting data information over a repeater allocated for data communication;

at the central controller:

(a) receiving said data channel request from the subscriber unit over said control channel;

(b) allocating, for time interval, said repeater for data communication to facilitate data communication between said computer and at least said subscriber unit.

14. A trunked communication system, having at least one central controller for allocating a plurality of communication channels among a plurality of subscriber units, and at least one network controller for controlling data transfers between a computer and at least one of said plurality of subscriber units, said system comprising:

at a subscriber unit:

means for transmitting a data channel request to the central controller over a control channel;

means for transmitting data information over a repeater allocated for data communication;

at the central controller:

means for receiving said data channel request from the subscriber unit over said control channel;

means for allocating, for a time interval, said repeater for data communication to facilitate data communication between said computer and at least said subscriber unit.

15. In a trunked communication system, having at least one central controller for allocating a plurality of communication channels among a plurality of subscriber units, and at least one network controller for controlling data transfers between a computer and at least one of said plurality of subscriber units, a method for allocating a data channel comprising the steps of:
- at a data-only subscriber unit:
 - (a) transmitting, regardless of whether a data channel has been assigned, a request to transmit data to the network controller over a predetermined channel;
 - at the network controller:
 - (a) receiving said request to transmit data from said predetermined channel;
 - (b) transmitting a data channel request to the central controller;
 - at the central controller:
 - (a) receiving said data channel request from the network controller;
 - (b) allocating, for a time interval, a repeater for data communication between said computer and at least said data-only subscriber unit.

16. A trunked communication system, having at least one central controller for allocating a plurality of communication channels among a plurality of subscriber units, and at least one network controller for controlling data transfers between a computer and at least one of said plurality of subscriber units, said system comprising:

at a data-only subscriber unit:

means for transmitting, regardless of whether a data channel has been assigned, a request to transmit data to the network controller over a predetermined channel;

at the network controller:

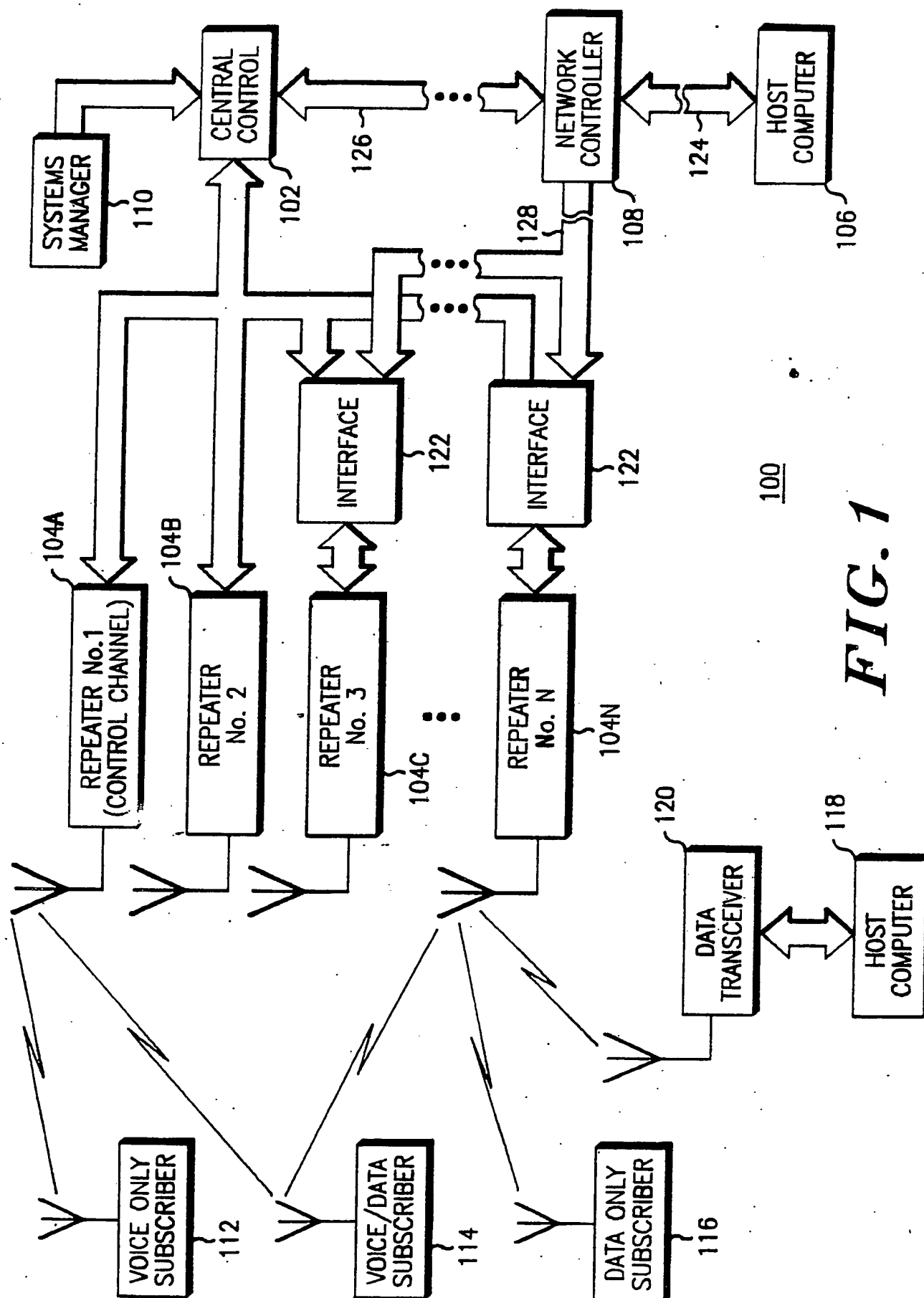
means for receiving said request to transmit data from said predetermined channel;

means for transmitting a data channel request to the central controller;

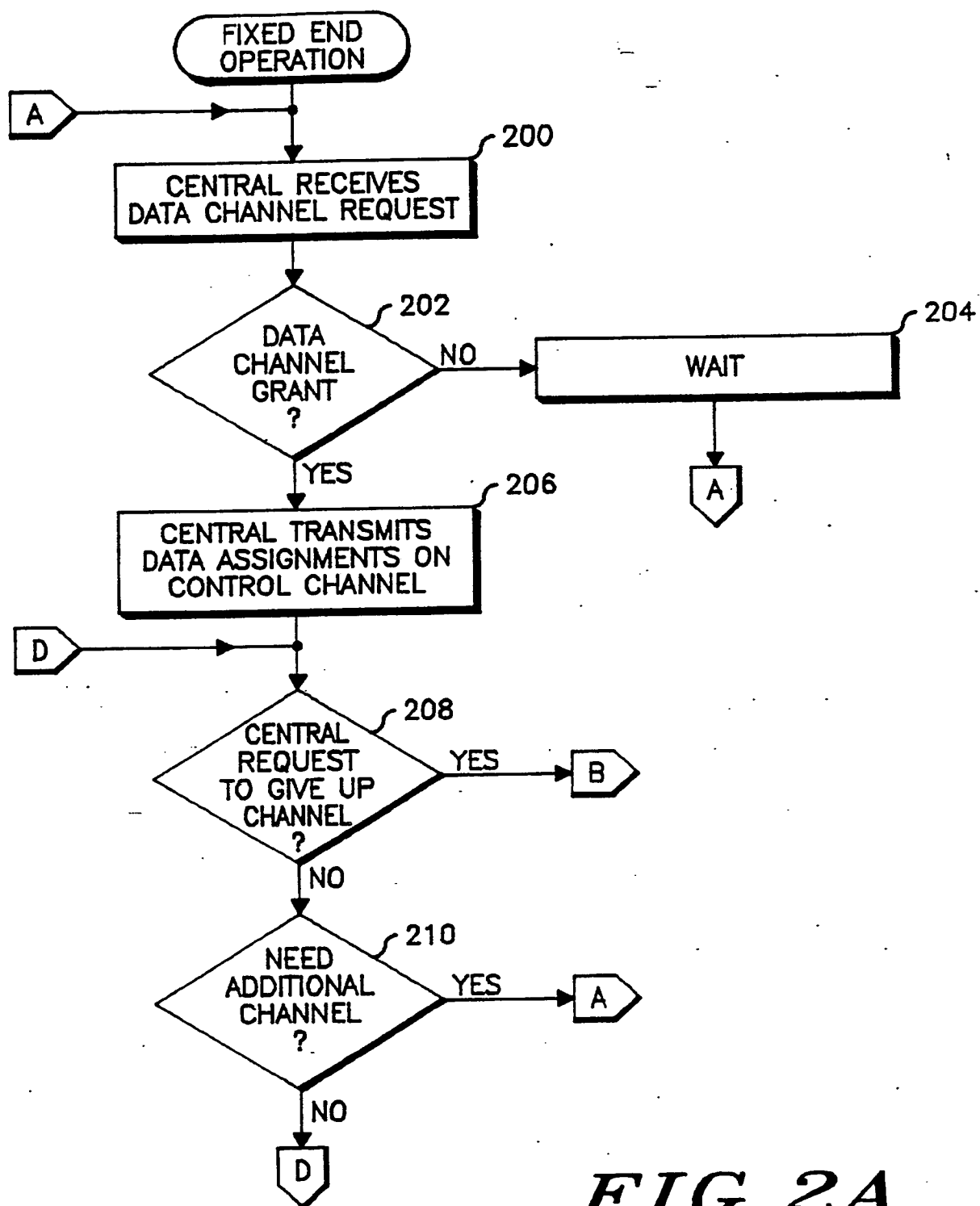
at the central controller:

means for receiving said data channel request from the network controller;

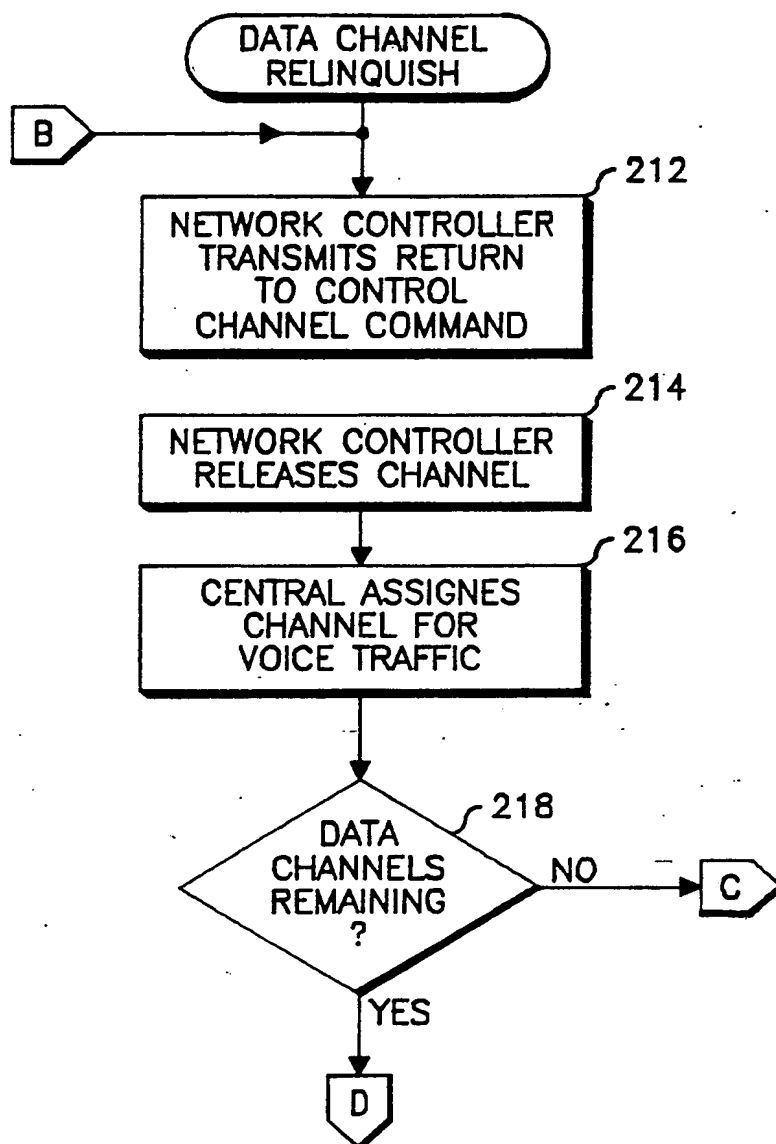
means for allocating, for a time interval, a repeater for data communication between said computer and at least said data-only subscriber unit.

**FIG. 1**

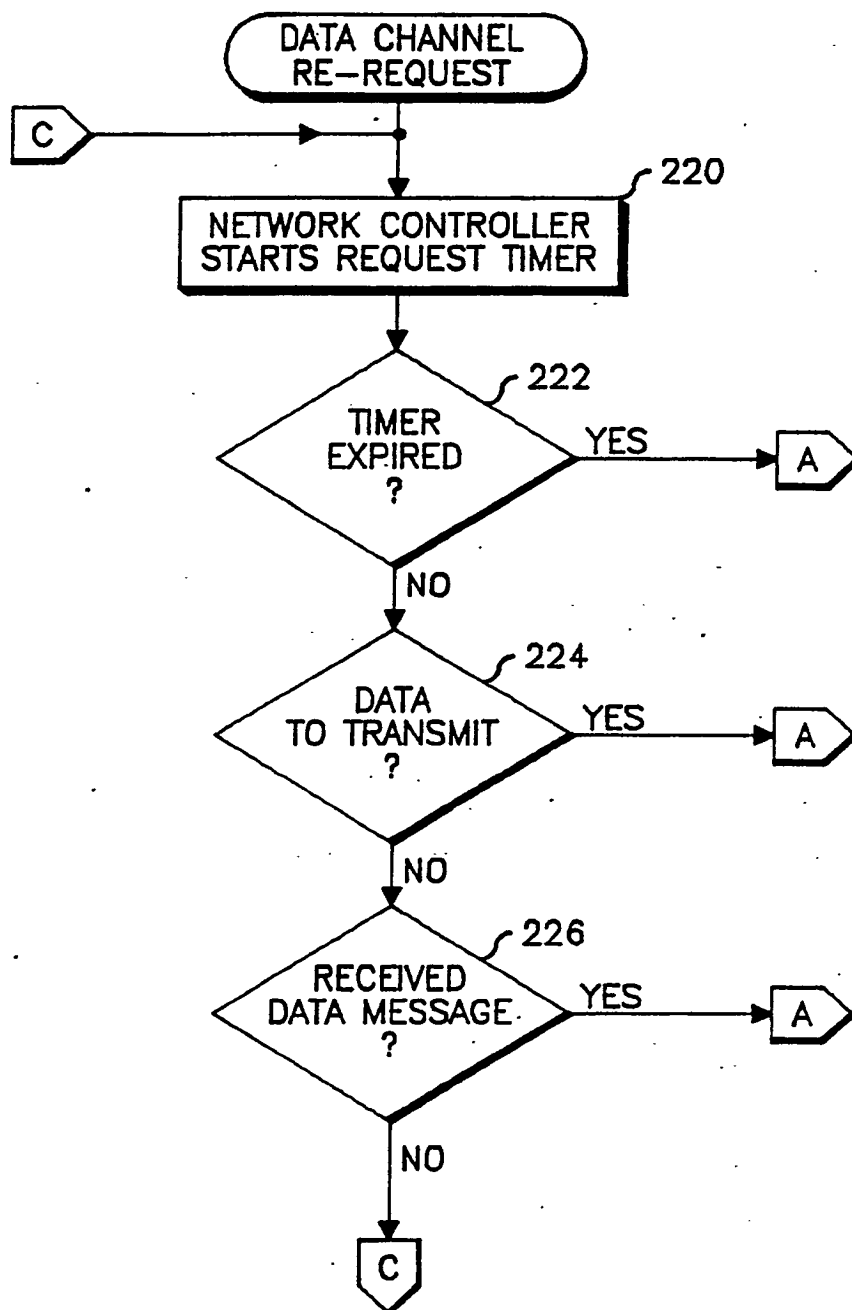
2/11

*FIG. 2A*

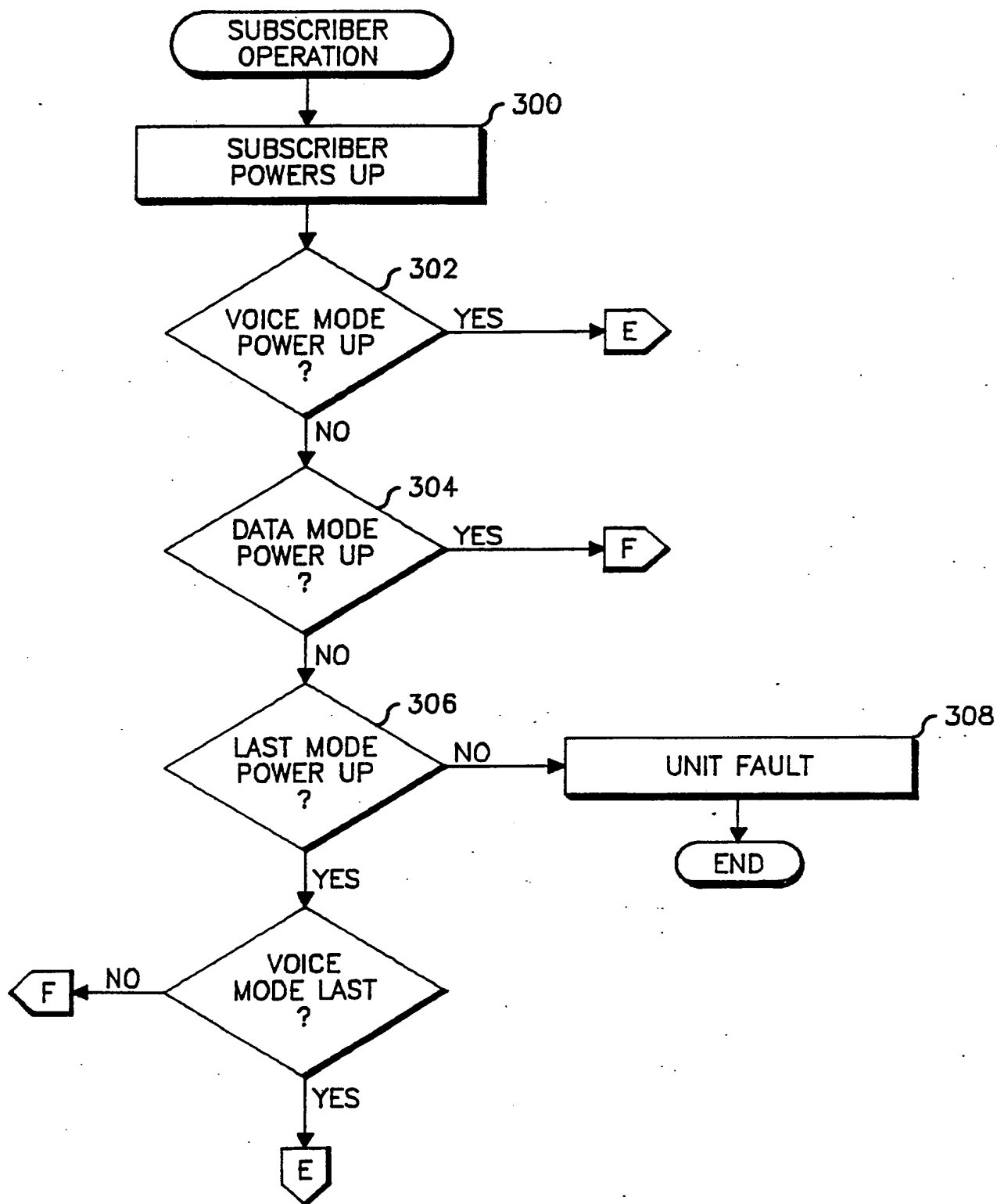
3/11

*FIG. 2B*

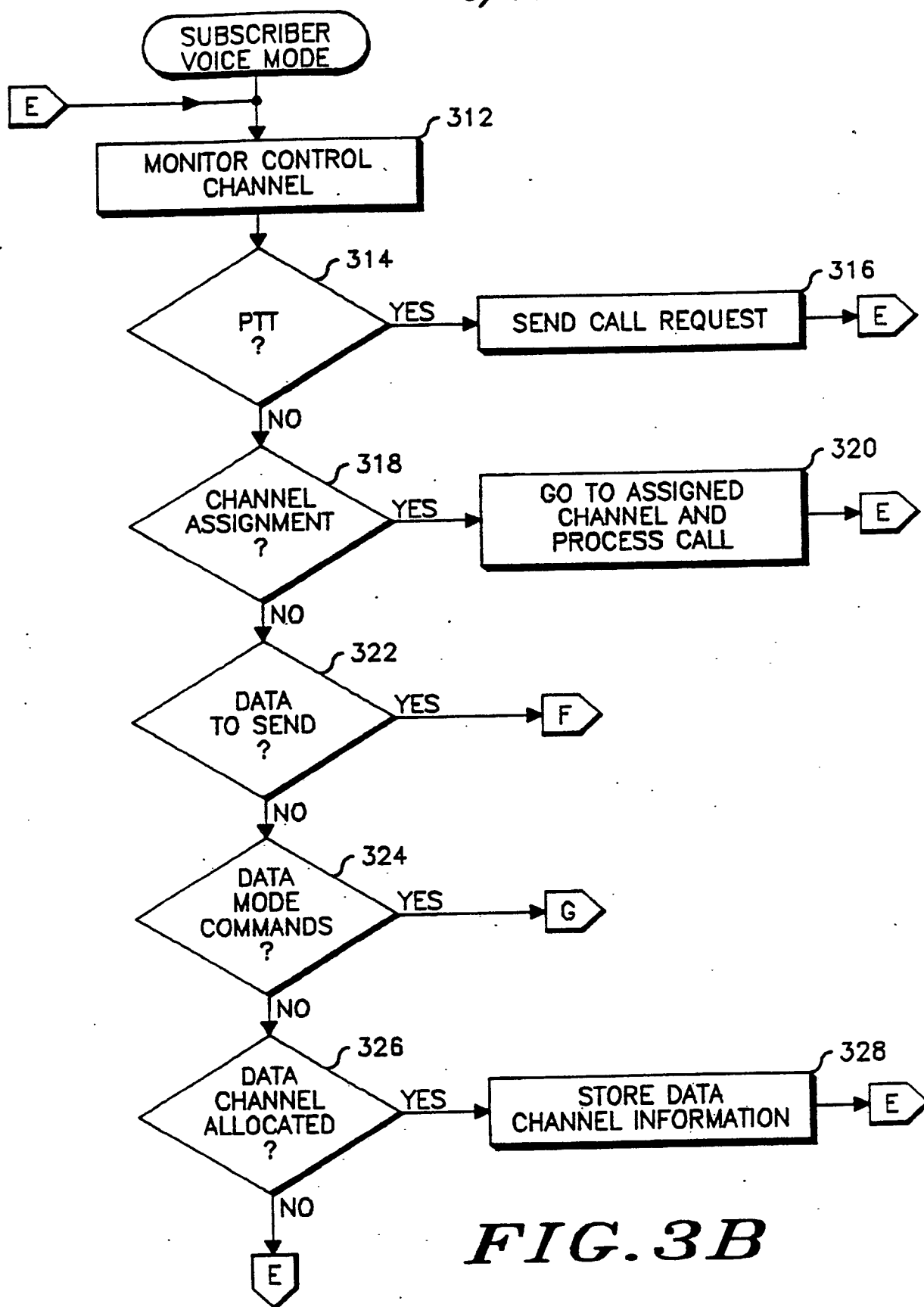
4/11

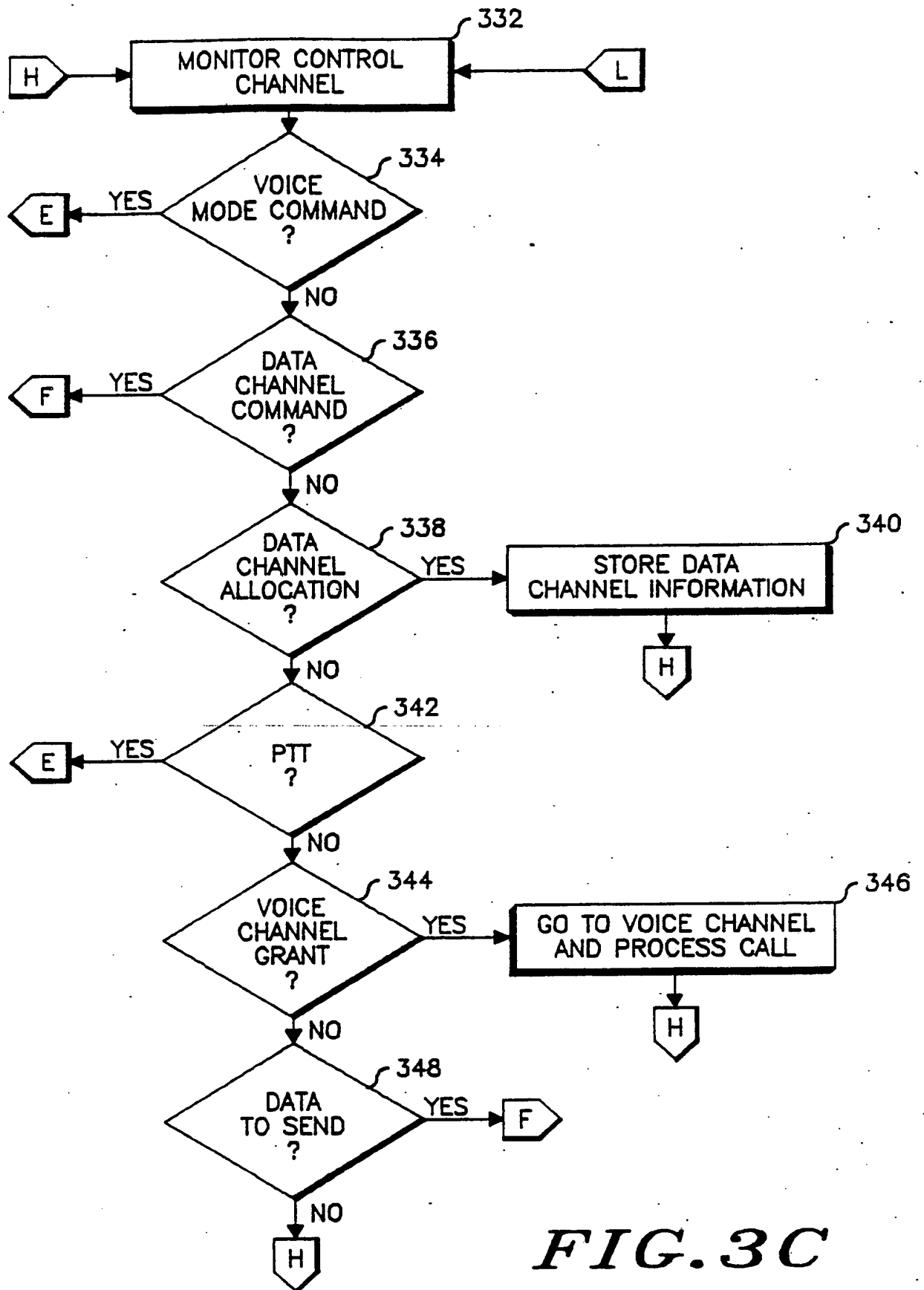
**FIG. 2C**

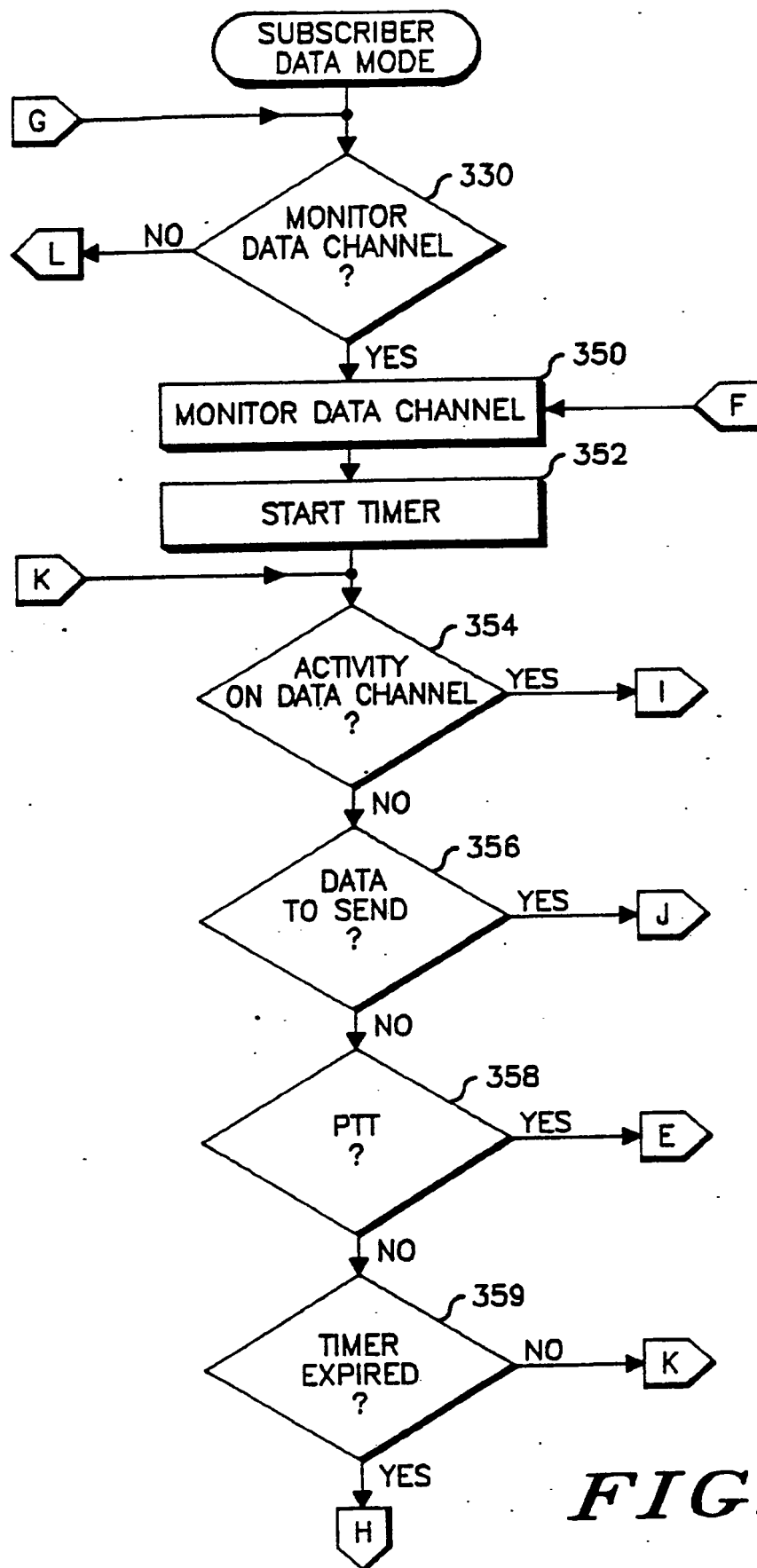
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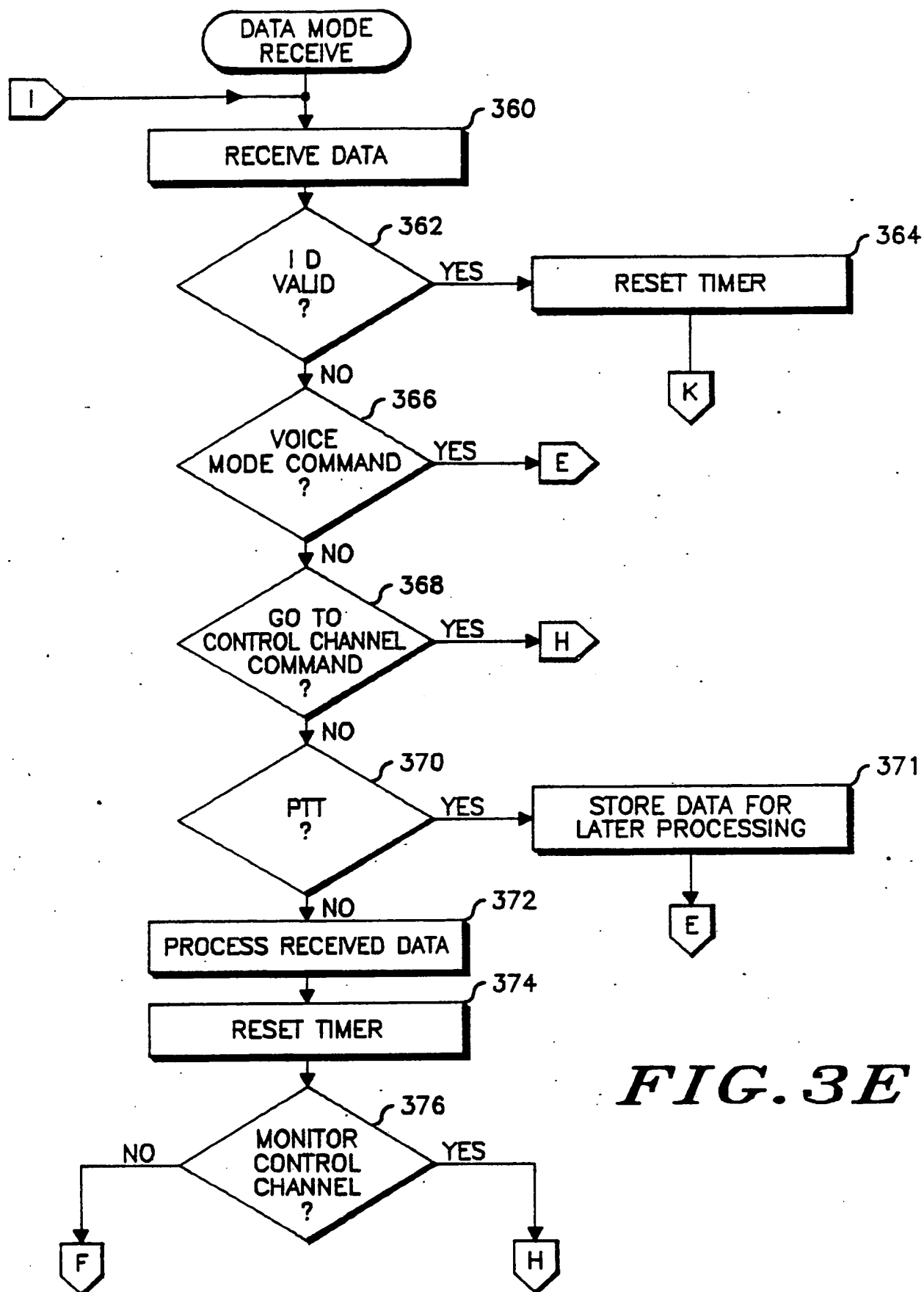
*FIG. 3A*

6/11

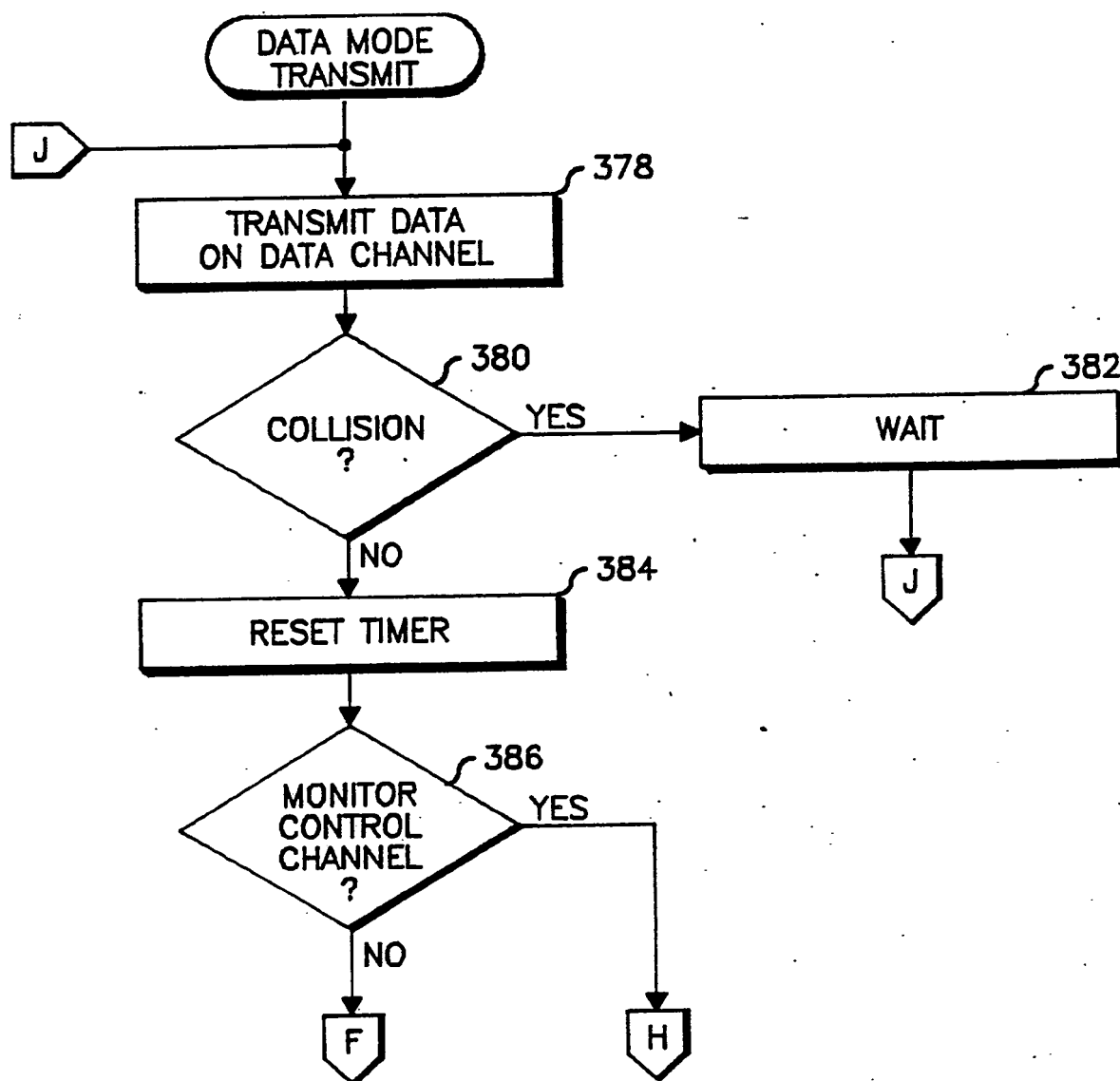
*FIG. 3B*

*FIG. 3C*

*FIG. 3D*

*FIG. 3E*

10/11

**FIG. 3F**

11/11

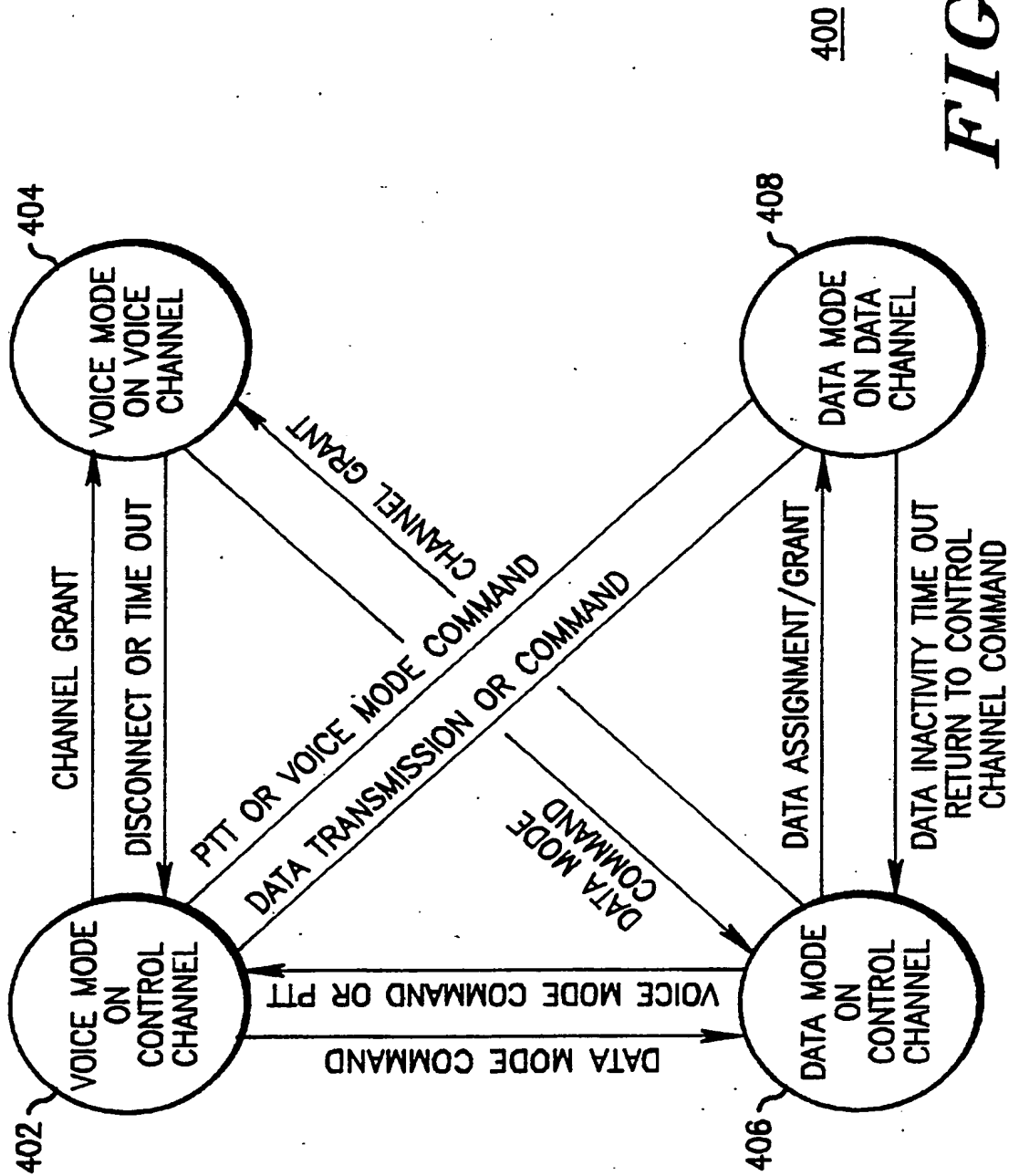


FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No. **PCT/US 88/00790**

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC IPC (4): H04B 7/00, 7/14 U.S. CL: 455/17, 32-34; 379/63											
II. FIELDS SEARCHED <div style="text-align: center; margin-top: 10px;">Minimum Documentation Searched ⁷</div> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 20%;">Classification System</th> <th>Classification Symbols</th> </tr> <tr> <td style="text-align: center; vertical-align: middle;">U.S.</td> <td>455/15, 17, 32-34, 54, 56; 379/63</td> </tr> </table> <div style="text-align: center; margin-top: 10px;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸</div>			Classification System	Classification Symbols	U.S.	455/15, 17, 32-34, 54, 56; 379/63					
Classification System	Classification Symbols										
U.S.	455/15, 17, 32-34, 54, 56; 379/63										
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹ <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 10%;">Category [*]</th> <th style="width: 70%;">Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²</th> <th style="width: 20%;">Relevant to Claim No. ¹³</th> </tr> <tr> <td style="vertical-align: top;">X, P</td> <td>U.S., A, 4,682,367 (Childress et al) 21 July 1987, See Figures 1 and 4, and column 1, line 15 - column 2, line 15.</td> <td style="text-align: center; vertical-align: top;">1</td> </tr> <tr> <td style="vertical-align: top;">A, P</td> <td>U.S., A, 4,672,601 (Ablay) 09 June 1987, See the entire document.</td> <td style="text-align: center; vertical-align: top;">1-6</td> </tr> </table>			Category [*]	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	X, P	U.S., A, 4,682,367 (Childress et al) 21 July 1987, See Figures 1 and 4, and column 1, line 15 - column 2, line 15.	1	A, P	U.S., A, 4,672,601 (Ablay) 09 June 1987, See the entire document.	1-6
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X, P	U.S., A, 4,682,367 (Childress et al) 21 July 1987, See Figures 1 and 4, and column 1, line 15 - column 2, line 15.	1									
A, P	U.S., A, 4,672,601 (Ablay) 09 June 1987, See the entire document.	1-6									
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>[*] Special categories of cited documents: ¹⁰</p> <ul style="list-style-type: none"> document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed </div> <div style="width: 45%;"> <ul style="list-style-type: none"> "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family </div> </div>											
IV. CERTIFICATION <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; vertical-align: top;"> Date of the Actual Completion of the International Search <div style="text-align: center; font-size: 1.2em;">26 April 1988</div> </td> <td style="width: 50%; vertical-align: top;"> Date of Mailing of this International Search Report <div style="text-align: center; font-size: 1.5em;">01 JUN 1988</div> </td> </tr> <tr> <td style="vertical-align: top;"> International Searching Authority <div style="text-align: center;">ISA/US</div> </td> <td style="vertical-align: top;"> Signature of Authorized Officer <div style="text-align: center;"> David H. Kim </div> </td> </tr> </table>			Date of the Actual Completion of the International Search <div style="text-align: center; font-size: 1.2em;">26 April 1988</div>	Date of Mailing of this International Search Report <div style="text-align: center; font-size: 1.5em;">01 JUN 1988</div>	International Searching Authority <div style="text-align: center;">ISA/US</div>	Signature of Authorized Officer <div style="text-align: center;"> David H. Kim </div>					
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